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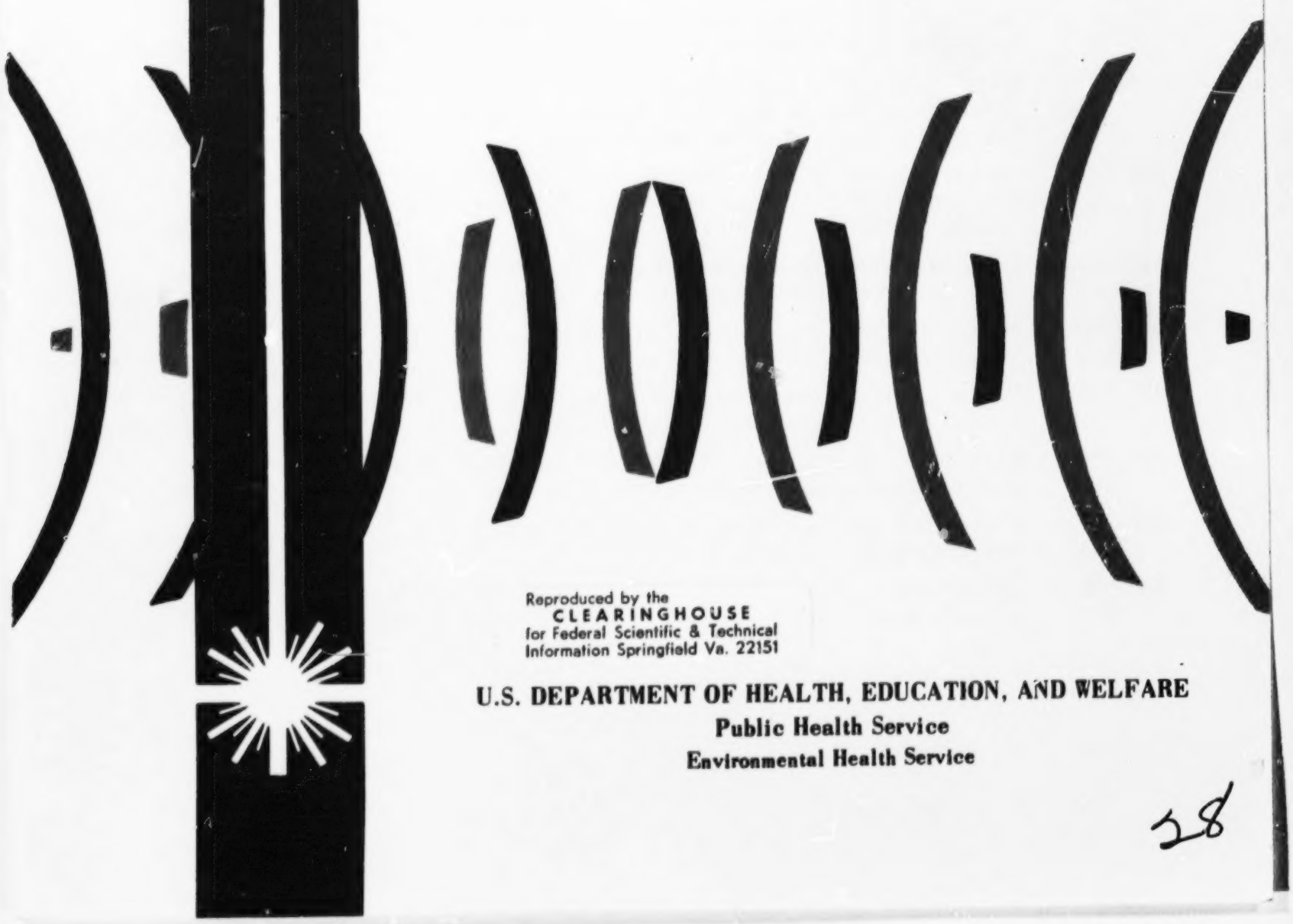
REPORT of TESTS for X-RAY EMISSION from a RAYOTRON® ELECTROSTATIC GENERATOR and PARTICLE ACCELERATOR



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DIVISION OF ELECTRONIC PRODUCTS

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BRH/DEP 70-22	Report of Tests for X-ray Emission from a Rayotron® Electrostatic Generator and Particle Accelerator (August 1970)	

BRH/DEP 70-22

REPORT of TESTS for X-RAY EMISSION from a RAYOTRON® ELECTROSTATIC GENERATOR and PARTICLE ACCELERATOR

Edwin A. Miller

Product Testing and Evaluation Branch
Division of Electronic Products

August 1970

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
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FOREWORD

The Bureau of Radiological Health, formerly the National Center for Radiological Health, continues to carry out a national program designed to reduce the exposure of man to hazardous ionizing and nonionizing radiation.

Within the Bureau, the Division of Electronic Products (1) develops and administers performance standards for radiation emissions from electronic products, (2) studies and evaluates emissions of and conditions of exposure to electronic product radiation and intense magnetic fields, (3) conducts or supports research, training, development, and inspections to control and minimize such hazards, and (4) tests and evaluates the effectiveness of procedures and techniques for minimizing such exposures.

The Bureau publishes its findings in Radiological Health Data and Reports (a monthly publication), Public Health Service numbered reports, appropriate scientific journals, and technical report series for the Bureau's divisions, offices, and laboratories.

The technical reports of the Division of Electronic Products (DEP) allow comprehensive and rapid publishing of the results of intramural and contractor projects. The reports are distributed to State and local radiological health program personnel, Bureau technical staff, Bureau advisory committee members, university radiation safety officers, libraries and information services, industry, hospitals, laboratories, schools, the press, and other interested individuals. These reports are also included in the collections of the Library of Congress and the Clearinghouse for Federal Scientific and Technical Information.

I encourage the readers of these reports to inform the Bureau of any omissions or errors. Your additional comments or requests for further information are also solicited.

John C. Villforth
Director
Bureau of Radiological Health

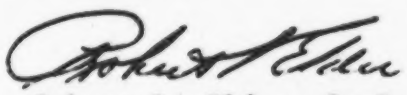
PREFACE

The National Council on Radiation Protection and Measurements (NCRP), in Report #32, has made recommendations regarding radiation protection in educational institutions. The report identifies gas-discharge tubes in general as potential sources of x rays and specifically mentions cold-cathode x-ray tubes in this regard.

The Bureau of Radiological Health has undertaken studies to identify those cold-cathode gas discharge devices used in educational institutions that may emit x radiation. The information obtained from these studies was used as supporting material for the development of performance standards for cold-cathode gas discharge devices used for educational purposes under the authority of the Radiation Control for Health and Safety Act of 1968 (Public Law 90-602). A proposed standard was published on January 30, 1970, and a revised version of the standard was published and became effective on May 19, 1970.

This report contains information on one such cold-cathode gas discharge device used in educational institutions. The work described herein was performed prior to publication of the final version of the standard, and the device was evaluated in regard to the requirements set forth in the proposed standard.

The manufacturer has been notified of the results of this project and informed that any such devices manufactured after May 19, 1970, are subject to the provisions of the standard.



Robert L. Elder, Sc.D.
Director
Division of Electronic Products

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ABSTRACT

This report describes a study undertaken by the Product Testing and Evaluation Branch to evaluate the radiation hazards associated with a small electrostatic generator and particle accelerator used for educational purposes. Laboratory measurements of the x-ray emission are presented, and comments are offered regarding the safety instructions provided with the device. Test findings are compared to the proposed performance standard for demonstration-type cold-cathode gas discharge tubes, since the final version of the standard had not been published at the time this work was performed.

REPORT OF TESTS FOR X-RAY EMISSION FROM A RAYOTRON® ELECTROSTATIC GENERATOR AND PARTICLE ACCELERATOR

INTRODUCTION

In 1969 the Bureau of Radiological Health conducted a joint Federal-State survey to determine the use of radiation-producing electronic apparatus in secondary school science instruction (1). One of the electronic products that is available for purchase by a high school science instructor, or any other person, and that has a definite potential for x-ray emission is a Rayotron® Electrostatic Generator and Particle Accelerator. The device uses the same principle employed in accelerators produced by major accelerator manufacturers for use in nuclear research, radiation therapy, and materials processing.

This report describes the laboratory testing and safety evaluation of the Rayotron. Other types of demonstration devices have previously been evaluated (2).

DESCRIPTION OF APPARATUS

The Rayotron is a Van de Graaff-type electrostatic generator and has a removable cold-cathode gas discharge x-ray tube (referred to by the manufacturer as a beam tube) available as an accessory (fig. 1). The generator has an 11-inch-diameter aluminum sphere and is advertised as being capable of reaching a potential of about a half-million volts. For operation as a particle accelerator and x-ray machine, the beam tube is positioned within the insulating column. High voltage is supplied to the cathode by the potential built up on the dome. X rays are produced when electrons are accelerated down the length of the tube (52 cm) and strike the anode. A phosphor coating at the anode end gives visual indication of the presence of high-energy electrons.

The control panel contains a microammeter to allow monitoring of either the charging or beam current, a rheostat to control the belt speed, and a power switch. In addition, there is a "power on" light and a "radiation" light which will illuminate only when the beam tube is in place. A toggle switch provides the operator with the option of having the warning lights on or off during operation.

The Rayotron is manufactured by Atomic Laboratories, Inc., a Division of Cenco Instrument Corporation. The Cenco catalog numbers for the generator and beam tube are 71865 and 71866, respectively.

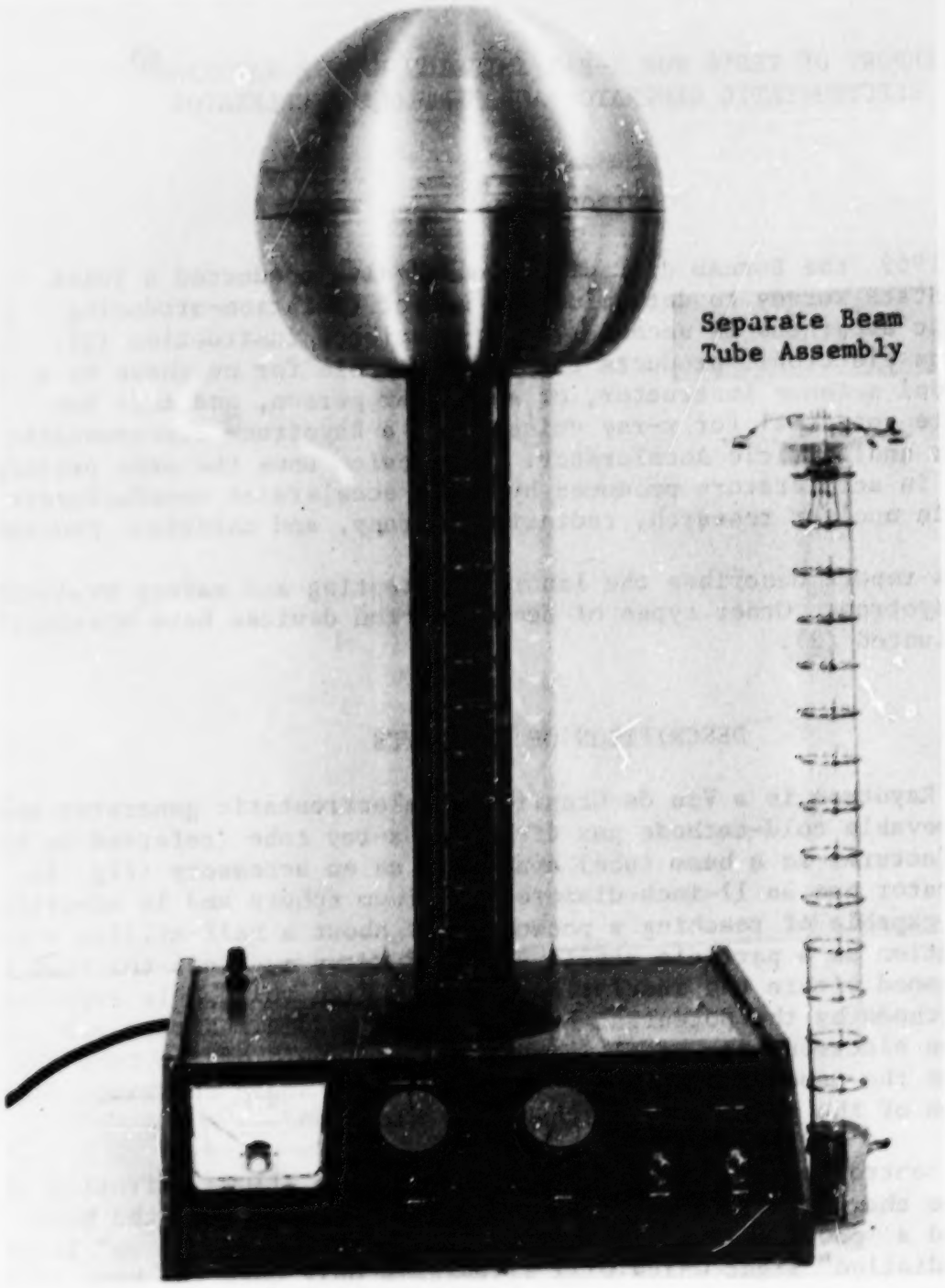

Figure 1. Rayotron electrostatic generator and particle accelerator with beam tube assembly in place.

The Bureau of Radiological Health purchased a Rayotron on February 3, 1969, at a cost of $390. The beam tube did not operate properly on receipt because of excessive gas pressure. A replacement tube, supplied by the manufacturer, was received on December 12, 1969.

The Operati Instructions (3) supplied with the Rayotron include an operation manual, a manual of experiments, an electrostatic generator syllabus, a section entitled "X-RAYS" and a bibliography. The stated purposes of the experiments using the Rayotron as an x-ray machine are: to gain familiarity with the appearance of Compton and photoelectrons as observed in a cloud chamber, to demonstrate the law of absorption of x rays in dense materials, and to demonstrate the inverse square law.

TEST OBJECTIVES

The objectives of tests performed on the Rayotron in the laboratories of the Product Testing and Evaluation Branch were:

a. To identify operating characteristics.

b. To measure x-ray emission levels and spatial distribution.

c. To determine the x-ray energy spectrum.

d. To evaluate the safety procedures listed in the Operating Instructions.

The findings were compared to the proposed performance standard for demonstration-type cold-cathode gas discharge tubes as published on January 30, 1970 (see appendix A). A revised version of the standard (see appendix B) was published and became effective on May 19, 1970. Any device manufactured after the effective date would have to meet the provisions of the standard.

TEST PROCEDURES

Initial estimates of x-ray exposure rates were made with a Victoreen model 440 R® portable ionization chamber survey instrument. Exposures were then measured using Victoreen Minometer® chambers (model 239-15) in conjunction with a Victoreen Minometer II® readout device (model 887C). The Minometer was chosen because it is relatively energy independent over a wide energy range and small exposures can easily be measured. The detector dimensions met the requirements prescribed in the proposed standard [78.211 (c) (2)]. The exposure rate was calculated from integrated two-minute exposures with corrections applied for the energy response characteristics of the Minometer. The effective energy estimated from the x-ray spectrum was used to arrive at the energy correction factor. In the energy range of 20 to 100 keV, the correction factors are within $\pm$ 10 percent of the value used.

In order to define radiation emission spatial distribution patterns, measurements were taken in three planes perpendicular to the vertical axis of the beam tube. The distance between the table top and the planes were 10, 30 and 58.5 centimeters, corresponding to the location of the anode, mid-height, and cathode, respectively. The Minometers in each plane were 30 centimeters from the insulating column and mounted on uprights located at each side of the base with the long axis of the chamber oriented normal to the axis of the beam tube. The chamber placed in front of the device and 30 centimeters from the table top was used as a reference point, and all other measurements were compared to it.

X-ray energy spectra were determined with a solid-state germanium detector coupled to a 1024 channel spectrum analyzer. Spectra obtained with the generator running at high and low current and with the ground wire connected and disconnected were compared. The maximum photon energy and effective energy of the beam were estimated from a plot of the spectrum.

TEST RESULTS

OPERATING CHARACTERISTICS

Charging and beam current

The charging and beam currents were not significantly different and were primarily functions of the belt speed and condition. Charge and beam currents ranged from 5 to 25μA at the motor speed just below that which would cause the belt to flutter. The 25μA current appeared as short period pulses at the beginning of the tests, while the current was fairly stable at 15μA. In the last few tests, 5μA was the highest attainable current, and the high-current surges were not observed.

Control of Radiation Emission

X-ray emission was directly related to the current passing through the beam tube and was a function of the belt speed, belt condition, and the gas pressure within the tube. Generally, a change in belt speed resulted in a corresponding change in x-ray output. At a constant belt speed, the output varied from instant to instant with no degree of consistency. Because of large instantaneous fluctuations, it was impossible to maintain constant x-ray emission over a time span greater than a few seconds. The x-ray emission rate decreased with the use of the tube as a result of changes in the gas pressure and belt deterioration. At the end of the test period, the output was less than 20 percent of that at the beginning.

RADIATION LEVELS

Radiation Distribution

The highest exposure rate observed at 30 centimeters from the insulating column was 550 mR/hr; the rate occurred in front of the device about midway on the length of the tube. The meter on the control panel indicated a beam current of 15μA at the time this measurement was taken.

Table 1 gives the radiation emission pattern around the Rayotron relative to the point of the highest exposure rate. All measurements were taken 30 centimeters from the insulating column.

The highest exposure rate from the original beam tube was observed to be 20 mR/hr. After 5 minutes of operation the exposure rate dropped to less than 10 mR/hr. Other measurements around this tube were not taken because of the low exposure rate.

Table 1. Radiation spatial distribution around the Rayotron.

Table top to minometer chamber (cm)	Relative intensity			
	Front	Rear	Right side	Left side
10	0.62	0.35	0.62	0.61
30	1.00	0.51	0.80	0.80
58.5	0.60	0.36	0.57	0.52

While 550 mR/hr was the highest x-ray exposure rate observed in these tests, it should not be assumed that other generators and beam tubes could not exceed this exposure rate. Tubes with different gas pressures operated by generators having belts in different condition may produce considerably different x-ray exposure rates. Sample data presented in the Operating Instructions indicate that the unit is capable of producing 1300 mR/hr at 48 centimeters from the insulating column.

Variation of Exposure Rate with Distance

The exposure rate was measured at intervals of 30 centimeters from the insulating column with the Minometer chamber in front of device and at a height 30 centimeters from the table top. Table 2 presents the data for the distance-exposure rate variations relative to the 30-centimeter distance. Because the beam tube does not act as a point source, the inverse square law is not followed.

Table 2. Relative reduction in radiation intensity with distance from insulating column.

Distance (cm)	Relative intensity
30	1.00
60	0.380
90	0.193
120	0.018

X-RAY ENERGY

The distribution of photon energies (fig. 2) is similar to that from other types of x-ray generators. The maximum photon energy was estimated from the spectrum to be approximately 80 keV. Spectra obtained under different conditions of operation were not significantly different, indicating that the photon energy distribution and maximum energy were independent of charge current and ground wire connection. The effective energy of the beam was estimated to be approximately 35 keV.

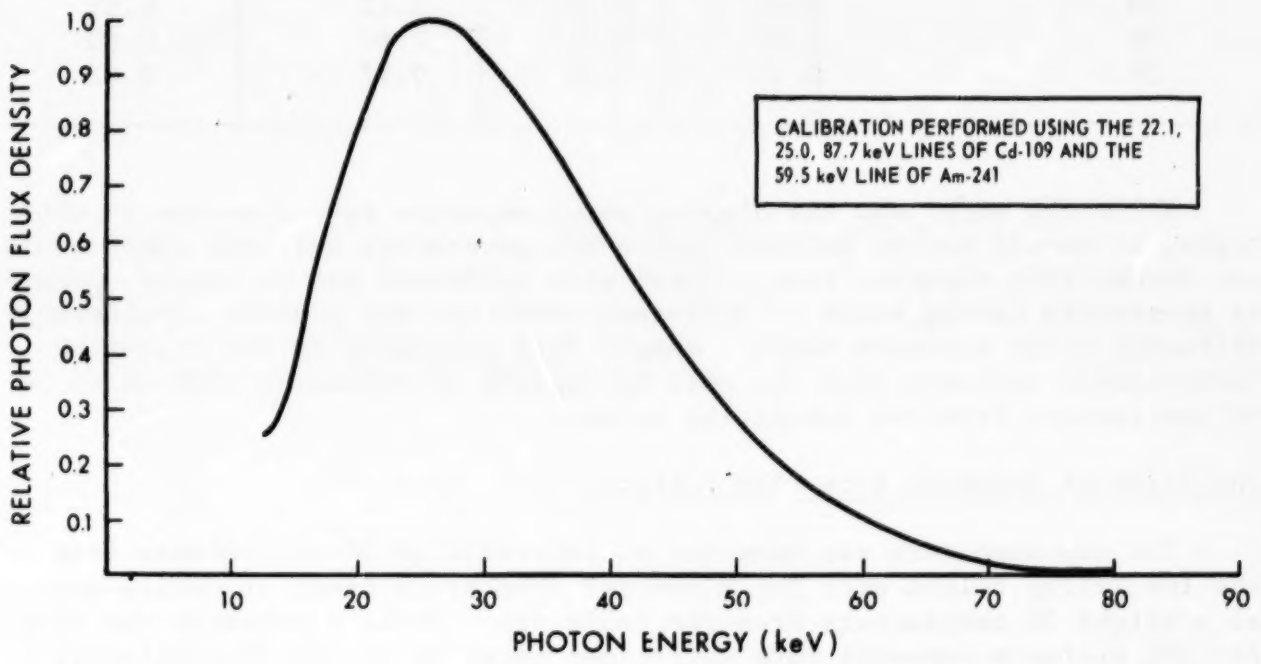

Figure 2. X-ray energy distribution for Rayotron electrostatic generator and particle accelerator.

COMMENTS ON SAFETY PRECAUTIONS SPECIFIED IN OPERATING INSTRUCTIONS

Shielding Instructions

The Operating Instructions furnished with the Rayotron suggest that a standard Bell and Spigot concrete pipe joint be placed around the device for shielding when the beam tube is operated for more than one minute. Dimensions specified are: 36 inches long, 24 inches inner diameter, and 2-1/4 inch wall thickness. The beam is to be allowed to exit through a 3/8-inch hole drilled 9 inches from the bottom. The price for the pipe length is stated to be about $10.

In our opinion, the method would most likely never be used because of the extreme inconvenience and cost involved. Local concrete pipe manufacturers have indicated that such a pipe length can be purchased only in 8-foot lengths and at a cost of approximately $42. The pipe would then have to be cut to the desired length by a piping contractor. The concrete pipe weighs approximately 270 pounds per foot and would appear to be too bulky and cumbersome to handle in the classroom situation. Furthermore, the controls of the device would be accessible only by extending the hand and arm down into the pipe, bringing the head close to or even touching the dome.

Assuming the quality of the x-ray beam approximates that of a 70-kVp x-ray machine, the half-value thickness is about 0.5 inch of concrete (5). Therefore, 2.25 inches of concrete would reduce the exposure rate to approximately 4.5 percent of the original exposure rate.

Plans for building shielding around the device are listed in the Cenco catalog for an extra $10. The plans are not included or mentioned in the Operating Instructions and have no catalog number assigned. These plans were not purchased and evaluated.

Table of Working Times

The Operating Instructions contain a table listing "safe" working times at various distances from the tube. The table is based upon the occupationally exposed guidelines of 100 mR/wk. A second column within the table lists times to give 20 mR in 24 hours. No reference is made to the NCRP Report 32 recommendations of 10 mR per experiment (4), although there is reference to NBS Handbook 59, "Permissible Doses from Ionizing Sources of Radiation."

The table of working time was derived using unshielded exposure rates given as sample data in the Operating Instructions. Although not stated, the table is calculated using the inverse square law and would be applicable to the x-ray beam coming through the exit port when the device is shielded according to the shielding instructions.

Beam Tube Reactivation

One method of beam tube reactivation prescribed in the Operating Instructions is to hold the tube by the target end and touch the upper gradient ring to a Tesla Coil. When the reactivation procedure was performed on the inoperative beam tube, x-ray exposure rates at the target end exceeded 300 mR/hr at contact. The same procedure performed on the replacement beam tube resulted in exposure rates of less than 10 mR/hr.

Warnings and Labels

The device had a built-in light that may be turned on to act as a warning light for possible x-ray production. The beam tube had to be in position and the machine turned on before it would illuminate. However, the light could be turned off by a switch on the control panel any time the operator desired. The light worked as designed for the original inoperative tube, but did not work for the replacement.

The base of the Van de Graaff had a warning label attached, stating the following:

"DANGER"

WHEN THE BEAM TUBE IS INSERTED THE X-RAY OUTPUT OF THE RAYOTRON IS EXCEEDINGLY HAZARDOUS, REACHING LEVELS AS HIGH AS 50 ROENTGENS PER HOUR ALONG THE ENTIRE LENGTH OF THE TUBE. THE RAYOTRON WITH BEAM TUBE INSERTED MUST THEREFORE NEVER BE OPERATED WITHOUT THE USE OF ADEQUATE MONITORING DEVICES AND WITHOUT THE SUPERVISION OF A TRAINED TECHNICIAN OR EXPERIENCED INSTRUCTOR WHO IS FAMILIAR WITH THE DANGERS OF UNSHIELDED X-RAY EQUIPMENT. THE OPERATOR SHOULD ALWAYS REMAIN AS FAR AS POSSIBLE FROM THE BEAM TUBE AND ALWAYS KEEP THE TIME OF EXPOSURE TO A MINIMUM. ALWAYS AVOID UNNECESSARY EXPOSURE. NEVER EXCEED AN EXPOSURE OF 0.1 ROENTGENS PER WEEK.

CONCLUSIONS

The findings of these tests are summarized and compared to the proposed performance standard (appendix A) below:

a. Exposure rate - The observed exposure rate of 550 mR/hr at 30 cm exceeded the 10 mR/hr at 30 cm limit established by the proposed standard [section 78.211 (c) (1) (i)].

b. Beam divergence - There was no means for limiting the x-ray beam, and there was no beam blocking device as required under the proposed standard [section 78.211 (c) (1) (ii)].

c. Instructions, labels, and warnings - The label, as applied, met the requirements of the proposed standard [section 78.211 (4) (ii) (c)]. It adequately warned of x-ray production; however, to be in accord with NCRP Report No. 32, the last sentence should be changed to 10 mR per experiment and 0.1 Rem per year.

The safety instructions supplied with the Operating Instructions were not appropriate. Based on weight and inaccessibility, the shielding instructions were thought to be impractical, and the table of working times was not sufficient to ensure adequate protection. Following the table of working times would result in exposures greater than those considered acceptable for students as a result of educational activities.

REFERENCES

(1) BUREAU OF RADIOLOGICAL HEALTH. Radiation sources in secondary schools - report of a limited survey. (ORO 69-S). U.S. Public Health Service (August 1969).

(2) PROPERZIO, W.S., R.C. WOODCOCK, AND S.D. HEIDERSDORF. X-ray emission from cold-cathode gas discharge tubes used for educational purposes.(BRH/DEP 70-1). U.S. Public Health Service. (February 1970).

(3) OPERATING INSTRUCTIONS - RAYOTRON ELECTROSTATIC GENERATOR AND PARTICLE ACCELERATOR - Catalog Nos. 71865 and 71866. Atomic Laboratories, Inc., a Division of Cenco Instruments Corporation, 1802 Foster Avenue, Chicago, Illinois 60640 (1959).

(4) NATIONAL COUNCIL ON RADIATION PROTECTION AND MEASUREMENTS. Radiation protection in educational institutions, NCRP Report No. 32. NCRP Publication, Washington, D.C. 20008 (July 1, 1966).

(5) NATIONAL BUREAU OF STANDARDS. Safety standards for non-medical x-ray and sealed gamma ray sources. Handbook 93. Washington, D.C. (1964).

APPENDIX A

PROPOSED RULE MAKING

1239

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

Public Health Service

[42 CFR Part 78]

DEMONSTRATION-TYPE COLD-CATHODE GAS DISCHARGE TUBES

Proposed Performance Standard

Pursuant to the authority contained in section 358 of the Radiation Control for Health and Safety Act of 1968 (42 U.S.C. 263f) and under authority delegated to the Commissioner of the Environmental Control Administration, it is proposed to amend Subpart C of Part 78 of Title 42, Code of Federal Regulations by prescribing a performance standard applicable to the emission of x-radiation from demonstration-type cold-cathode gas discharge tubes.

The development of the standard began after studies by the Bureau of Radiological Health revealed that these tubes could emit excessive radiation. Research by the Bureau of Radiological Health, in cooperation with State health agencies, confirmed that these tubes are often used in high schools where students under the age of 18 years could be exposed. The National Council of Radiation Protection and Measurements (NCRP) recommended in July of 1966 that students under 18 years of age, while participating in educational activities, should not receive a radiation dose equivalent which exceeds 100 millirem per year (mrem/yr), nor should they receive a radiation dose equivalent which exceeds 10 millirem during any one experiment. The Bureau of Radiological Health bases the promulgation of the exposure rate limit of 10 milliroentgens per hour (mR/hr) below upon these recommendations by the NCRP. In consulting with appropriate professional organizations, interested persons, and the Technical Electronic Product Radiation Safety Standards Committee as required by section 358 of the Act, it was determined that this exposure rate limit is reasonable, technically feasible, and will protect the public health and safety.

Discussions with representatives of the public, other governmental agencies and the industry affected, have resulted in a finding that the standard should be applicable to cold-cathode gas discharge tubes at the earliest possible time. The need for the protection of the public health and safety and the special use of this electronic product constitute good cause for a finding that an early effective date for the standard is in the public interest. Accordingly, this amendment shall become effective on the date of its republication in the FEDERAL REGISTER.

Inquiries may be addressed to, and data, views, and arguments may be submitted in writing to, the Director, Bureau of Radiological Health, 12720 Twinbrook Parkway, Rockville, Md. 20852. All relevant material received within 30 days after publication of this notice in the FEDERAL REGISTER will be considered.

The amendment to Subpart C of Part 78 would read as follows:

§ 78.211 Performance standard for cold-cathode gas discharge tubes.

(a) *Applicability.* The provisions of this section are applicable to cold-cathode gas discharge tubes designed to demonstrate the effects of a flow of electrons or the production of x-radiation.

(b) *Definitions.* "Beam blocking device" means a movable or removable portion of any enclosure around a cold-cathode gas discharge tube, which may be opened or closed to permit or prevent the emergence of an exit beam.

"Cold-cathode gas discharge tube" means an electronic device in which electron flow is produced and sustained by ionization of contained gas atoms and ion bombardment of the cathode.

"Exit beam" means that portion of the radiation which passes through the aperture resulting from the opening of the beam blocking device.

"Exposure" means the sum of the electrical charges on all of the ions of one sign produced in air when all electrons liberated by photons in a volume element of air are completely stopped in air divided by the mass of the air in the volume element. The special unit of exposure is the roentgen. One (1) roentgen equals 2.58×10^{-4} coulombs/kilogram.

(c) *Requirements.* (1) *Exposure rate limit.* (i) Radiation exposure rates produced by cold-cathode gas discharge tubes shall not exceed 10 mR/hr at a distance of thirty (30) centimeters from any point on the external surface of the tube, as measured in accordance with this section.

(ii) The divergence of the exit beam from tubes designed primarily to demonstrate the effects of x-radiation, with the beam blocking device in the open position, shall not exceed π (Pi) steradians.

(2) *Measurements.* (i) Compliance with the exposure rate limit defined in (c) (1) (i) shall be determined by measurements averaged over an area not greater than one hundred (100) square centimeters with no linear dimension greater than twenty (20) centimeters.

(ii) Measurements of exposure rates from tubes in enclosures from which the tubes cannot be removed without destroying the function of the tube may be made at a distance of thirty (30) centimeters from any point on the external surface of the enclosure, provided:

(a) In the case of enclosures containing tubes designed primarily to demonstrate the production of x-radiation, measurements shall be made with any beam blocking device in the beam blocking position, or

(b) In the case of enclosures containing tubes designed primarily to demonstrate the effects of a flow of electrons, measurements shall be made with all movable or removable parts of such enclosure in the position which would maximize external exposure levels.

(3) *Test conditions.* (i) Measurements shall be made under the conditions of use specified in instructions provided by the manufacturer.

(ii) Measurements shall be made with the tube operated under forward and reverse polarity.

(4) *Instructions, labels, and warnings.* (i) Manufacturers shall provide, or cause to be provided, with each tube to which this section is applicable, appropriate safety instructions, together with instructions for the use of such tube, including the specification of a power source for use with the tube.

(ii) Each enclosure or tube shall have inscribed on or permanently affixed to it, tags or labels, which: (a) Indentify the intended polarity of the terminals; (b) in the case of tubes designed primarily to demonstrate the effects of a flow of electrons, a warning that application of power in excess of that specified may result in the production of X-rays in excess of allowable limits; and (c) in the case of tubes designed primarily to demonstrate the production of x-radiation, a warning that this device produces X-rays when energized.

(iii) The tag or label required by this paragraph shall be located on the tube or enclosure so as to be readily visible and legible when the product is fully assembled for use.

This action is proposed under the authority of Sec. 358, 82 Stat. 1177; 42 U.S.C. 263f.

Dated: December 19, 1969.

CHRIS A. HANSEN,
Commissioner, ECA.

[F.R. Doc. 70-1198; Filed, Jan. 29, 1970; 8:47 a.m.]

APPENDIX B

PERFORMANCE STANDARD FOR DEMONSTRATION-TYPE COLD-CATHODE GAS DISCHARGE TUBES

FEDERAL REGISTER

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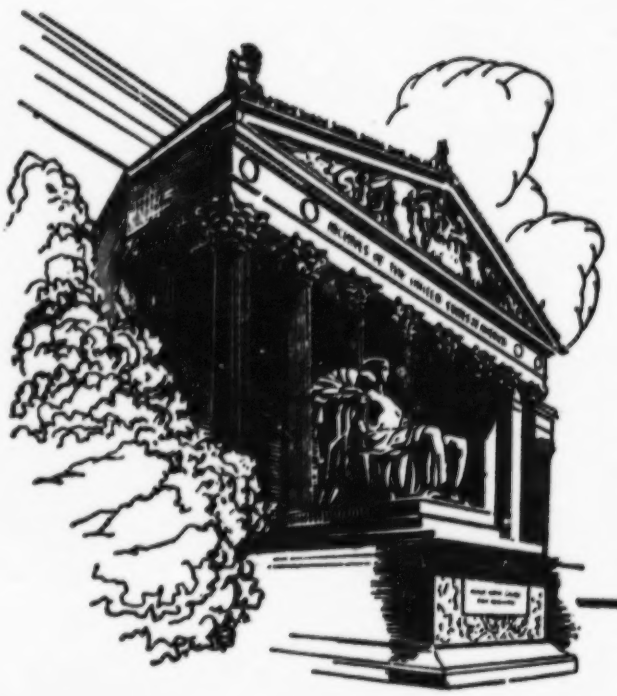

Title 42—PUBLIC HEALTH

Chapter I—Public Health Service, Department of Health, Education, and Welfare

SUBCHAPTER F—QUARANTINE, INSPECTION, LICENSING

PART 78—REGULATIONS FOR THE ADMINISTRATION AND ENFORCEMENT OF THE RADIATION CONTROL FOR HEALTH AND SAFETY ACT OF 1968

Performance Standard for Demonstration-Type Cold-Cathode Gas Discharge Tubes

THE NATIONAL ARCHIVES OF THE UNITED STATES • 1934 •

FEDERAL REGISTER (35 F.R. 1239-1240) to amend Part 78 by prescribing a performance standard applicable to the emission of radiation from demonstration-type cold-cathode gas discharge tubes.

Interested persons were given the opportunity to participate in the rule making through the submission of comments. Due consideration has been given to all relevant material presented in response to the notice.

Changes in the amendment as proposed include revision of the labeling section and revision of the measurement area.

The Commissioner has determined that the need for protection of the public health and safety, particularly in the use of such tubes in educational institutions, constitutes sufficient cause for an early effective date for the standard. Accordingly, this amendment shall become effective on the date of publication in the FEDERAL REGISTER. The amendments to Subpart C of Part 78 are as follows:

1. The center heading preceding § 78.210 is changed to read "Performance Standards."

2. Section 78.211 is added to read as follows:

§ 78.211 Performance Standard for Cold-Cathode Gas Discharge Tubes.

(a) *Applicability.* The provisions of this section are applicable to cold-cathode gas discharge tubes designed to demonstrate the effects of a flow of electrons or the production of x radiation as specified herein.

(b) *Definitions.* "Beam blocking device" means a movable or removable portion of any enclosure around a cold-cathode gas discharge tube, which may be opened or closed to permit or prevent the emergence of an exit beam.

"Cold-cathode gas discharge tube" means an electronic device in which electron flow is produced and sustained by ionization of contained gas atoms and ion bombardment of the cathode.

"Exit beam" means that portion of the radiation which passes through the aperture resulting from the opening of the beam blocking device.

"Exposure" means the sum of the electrical charges on all of the ions of one sign produced in air when all electrons liberated by photons in a volume element of air are completely stopped in air divided by the mass of the air in the volume element. The special unit of exposure is the roentgen. One (1) roentgen equals 2.58×10^{-4} coulombs/kilogram.

(c) *Requirements.* (1) Exposure rate limit:

(i) Radiation exposure rates produced by cold-cathode gas discharge tubes shall not exceed 10 mR./hr. at a distance of thirty (30) centimeters from any point on the external surface of the tube, as measured in accordance with this section.

(ii) The divergence of the exit beam from tubes designed primarily to demonstrate the effects of x radiation, with the beam blocking device in the open position, shall not exceed π (Pi) steradians.

(2) Measurements:

(i) Compliance with the exposure rate limit defined in (c)(1)(i) shall be determined by measurements averaged over an area of one hundred (100) square centimeters with no linear dimension greater than twenty (20) centimeters.

(ii) Measurements of exposure rates from tubes in enclosures from which the tubes cannot be removed without destroying the function of the tube may be made at a distance of thirty (30) centimeters from any point on the external surface of the enclosure, provided:

(*a*) In the case of enclosures containing tubes designed primarily to demonstrate the production of x radiation, measurements shall be made with any beam blocking device in the beam blocking position, or

(*b*) In the case of enclosures containing tubes designed primarily to demonstrate the effects of a flow of electrons, measurements shall be made with all movable or removable parts of such enclosure in the position which would maximize external exposure levels.

(3) Test conditions:

(i) Measurements shall be made under the conditions of use specified in instructions provided by the manufacturer.

(ii) Measurements shall be made with the tube operated under forward and reverse polarity.

(4) Instructions, labels, and warnings:

(i) Manufacturers shall provide, or cause to be provided, with each tube to which this section is applicable, appropriate safety instructions, together with instructions for the use of such tube, including the specification of a power source for use with the tube.

(ii) Each enclosure or tube shall have inscribed on or permanently affixed to it, tags or labels, which identify the intended polarity of the terminals and: (a) In the case of tubes designed primarily to demonstrate the heat effect, fluorescence effect, or magnetic effect, a warning that application of power in excess of that specified may result in the production of x rays in excess of allowable limits; and (b) in the case of tubes designed primarily to demonstrate the production of x radiation, a warning that this device produces x rays when energized.

(iii) The tag or label required by this paragraph shall be located on the tube or enclosure so as to be readily visible and legible when the product is fully assembled for use.

(Sec. 358, 82 Stat. 1177; 42 U.S.C. 263f)

RAYMOND T. MOORE,
Acting Commissioner, Environmental Control Administration.

[F.R. Doc. 70-6016; Filed, May 18, 1970; 8:45 a.m.]

Title 42—PUBLIC HEALTH

Chapter I—Public Health Service, Department of Health, Education, and Welfare

SUBCHAPTER F—QUARANTINE, INSPECTION, LICENSING

PART 78—REGULATIONS FOR THE ADMINISTRATION AND ENFORCEMENT OF THE RADIATION CONTROL FOR HEALTH AND SAFETY ACT OF 1968

Performance Standard for Demonstration-Type Cold-Cathode Gas Discharge Tubes

On January 30, 1970, notice of proposed rule making was published in the

The following information reproduced from the Federal Register, Vol. 34, No. 247 - Thursday, December 25, 1969 is presented for your information:

Subpart C—Performance Standards for Electronic Products

General Provisions

§ 78.200 Scope.

The standards listed in this subpart are prescribed pursuant to section 358 of the Radiation Control for Health and Safety Act of 1968 (42 U.S.C. 263f) and are applicable to electronic products as specified herein, to control electronic product radiation from such products. Standards so prescribed are subject to amendment or revocation and additional standards may be prescribed as are determined necessary for the protection of the public health and safety.

§ 78.201 Certification.

(a) Every manufacturer of an electronic product to which an applicable standard is in effect under this subpart, shall furnish to the dealer or distributor at the time of delivery of such product, the certification that such product conforms to all applicable standards under this subpart.

(b) The certification shall be in the form of a label or tag permanently affixed to, or inscribed on such product. In the case of products to which it is not feasible to affix or inscribe the label or tag, upon application therefor, the Secretary may approve other means by which a manufacturer may provide the certification required by this section.

(c) Such certification shall be based upon a test, in accordance with the standard, of the individual article to which it is attached or upon a testing program which is in accordance with good manufacturing practices. The Secretary may disapprove such a testing program on the grounds that it does not assure the adequacy of safeguards against hazardous electronic product radiation or that it does not assure that electronic products comply with the standard prescribed under this subpart.

(d) The certification tag or label or inscription shall be located on the product so as to be legible when the product is fully assembled for use.

§ 78.202 Labeling.

Every manufacturer of an electronic product to which is applicable a standard under this subpart shall, by a label or tag permanently affixed to or inscribed on such product, set forth:

(a) The full name and address of the manufacturer of the product: Abbreviations such as "Co.," "Inc.," or their foreign equivalents and the first and middle initials of individuals may be used. Where products are sold under a name other than that of the manufacturer of the product, the label may set forth the name of the individual or company under whose name the product was sold, provided such individual or company has previously supplied the Secretary with sufficient information to identify the manufacturer of the product.

(b) The month, year, and place of manufacture: This information may be expressed in code provided the manufacturer has previously supplied the Secretary with the key to such codes.

(c) The tag or label shall be located on the product so as to be legible when the product is fully assembled for use.

§ 78.203 Special test procedures.

The Secretary may, on the basis of a written application by a manufacturer, authorize test programs other than those set forth in the standard for an electronic product if he determines that such products are not susceptible to satisfactory testing by the procedures set forth in the standard and that the alternative test procedures assure compliance with the standard.

§ 78.204 Electronic products intended for export.

The performance standard prescribed in this subpart shall not apply to any electronic product which is intended solely for export if (a) such product and the outside of any shipping container used in the export of such product are labeled or tagged to show that such product is intended for export, and (b) such product meets all the applicable requirements of the country to which such product is intended for export.

* U. S. GOVERNMENT PRINTING OFFICE : 1970— 613/25

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Edwin A. Miller
REPORT OF TESTS FOR X-RAY EMISSION FROM A RAYOTRON® ELECTROSTATIC GENERATOR AND PARTICLE ACCELERATOR.
U.S. Department of Health, Education, and Welfare, Public Health Service Publication Number BRH/DEP 70-22 (August 1970), 20 pp. (limited distribution).

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